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REVIEW OF THE USE OF BIOLOGICAL INGREDIENTS AS A BIOCIDE TO CONTROL MOSQUITO POPULATION WORLDWIDE

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ABSTRACT

Mosquitoes are responsible for the transmission of vectors of many dreadful diseases. It carries the vectors like encephalitis virus, West Nile virus, yellow fever & lymphatic filariasis. Mosquitoes show complete metamorphosis i.e. eggs, larva, pupa & adult. It is very easy to control mosquitoes at the larval & pupal stages as the stages are aquatic while adults are not easy to control as they are actively fly in the air. From many years ago we are trying to control mosquitoes with the help of many chemical insecticides. But the increased use of chemical pesticides causes harmful effects on the environment, human beings & insects useful to mankind. Mosquitoes develop resistance to the chemical insecticide. Since now a day eco-friendly approaches are made to control mosquito larvae by using plant extracts as an alternative to chemical insecticides. Many plant species exhibited mosquitocidal, larvicidal & pupicidal activity against the various species of mosquitoes at adult, larval & pupal stages respectively. So many workers made the herbal extracts using different solvents and tested them against different stages of various species of mosquitoes. Not only the plants but the other animals as well as plants and animals from marine habitat are also used for controlling the mosquito population. Many researchers work on various animals as well as marine life which are used to control the mosquito population in the world. So in this research paper, we will do a review on the use of the herbal extracts as well as the other biological agents used in the mosquito control programs. The current state of knowledge on phytochemical sources and their larvicidal activity, their mode of action in the Culex mosquito larvae, is summarized in the present article. Hence, this review can give a clear idea of the use of herbal extracts against mosquito vectors.

Keywords- Culex, plant extracts, insecticides.

INTRODUCTION

Mosquitoes are distributed worldwide except the places which are covered by ice. They are distributed in tropical & subtropical regions of the world. Mosquitoes are likely to transmit diseases from patient to healthy person. The transmission of diseases such as Malaria, chikungunya, Dengue, Filariasis & Japanese encephalitis in more than $2/5^{th}$ of the world population[4]. To minimize such dreadful diseases, extensive research has been done to control the mosquito population for few decades. The research was carried out in many

fields like physiology, behavior science, ecology, systemic morphology, & disease epidemiology etc. Now a day the research in genetics & molecular biology also contributed to the mosquito control program [5].

Vector control programs face many problems because of the increased resistance to synthetic insecticides. Alternative biological control measures including the introduction of parasites, pathogens & predators are used to control mosquitoes. This biocontrol using pathogens are generally done with microbial pathogens like *Bacillus thuringenesis* (Bti) & *Bacillus spaericus* [6].

Plants are a rich source of alternative agents for the control of mosquitoes, as they possess many bioactive chemicals. These bioactive chemicals act against a limited number of species including specific target insects & are eco-friendly [1]. Traditionally plant-based products have been used in human communities for many centuries for controlling different insect pests. The majority of the secondary metabolites present in plants serve as defense mechanisms against insect attacks. These bioactive chemicals act as insecticides, repellants, growth inhibitors, molting hormones, antifeedants, juvenile hormone mimics as well as an attractant. They are less toxic, delay the development of resistance & are easily biodegradable[2]. Several plant extracts, as well as isolated compounds from different plant families, have been evaluated for their promising larvicidal activities [3]. This study mainly focused on the use of plant-based insecticides against mosquitoes.

Different extracts obtained from many plant parts like leaves, stem, roots, flowers & seeds in their crude extracts have been used as a promising conventional larvicide. Deepak Kumar et al. [7] studied the larvicidal activity of petroleum ether & N-butanol whole plant extract of *Cassia occidentalis* against the *Culex* due to the presence of flavonoids, phenols, glycosides & tannins. The estimated LC50 & LC90 values for *Cassia occidentalis*, petroleum ether & ethyl N-butanol extracts were 98.4ppm & 173.8 ppm as well as 161.6 ppm & 230ppm respectively. *Azadirachta indica* constitutes the active compound like limonoids of azadiractin, salannin, deacetylegedunin, gedunin, 17- hydroxyazadiradione & deacetylenimbinthe. Alouani et al. [8] tested the extract of *Azadirachta indica* against the fourth instar larvae of *Culex pipens* at the different concentrations which exhibited more the 85% larvicidal activity at 1ppm & LC_{50} value was 0.50 ppm. Also, the extract showed an increased larval duration of up to 19 days. From the study of Okigbo et al. [9] it is clearly indicated that the petroleum ether extract of *A. indica*, was tested against the *Culex* sp. at different concentration like 40, 35, 25 & 20% in which 100% larvicidal activity was observed at 35 & 40% concentration with the LC_{50} values of 14.3ppm. Maragathavalli et al. [10] tested the methanol & ethanol leaf extracts of *A. indica* against *Ae. aegypti* & *Culex quinquefasciatus*. The methanolic extract of *A. indica* showed the 90 & 70 % mortality at 200mg/100ml & 150mg/100ml concentration against *Ae. aegypti* & *Culex quinquefasciatus* respectively. The ethanolic extract of *A. indica* shows 85 & 90% mortality at 200mg/100ml &

120mg/100ml concentration against *Ae. aegypti* & *Culex quinquefasciatus* respectively. Monzon et al. [11] reported that aqueous extract of *L. domesticum* showed larvicidal activity against *Ae. aegypti* & *Culex quinquefasciatus*.

Using four different concentrations like 100, 200, 300 and 500 microgram /ml. Preeti Sharma et al. [13] reported the disturbed metabolic activity of the *Culex* and *Anopheles* larva after the treatment of *A. annua* and *Az. indica*. Carbohydrate, total lipid and protein estimation was done after the use of the petroleum ether and methanolic extracts of *A. annua* and *Az. indica* which indicate an alteration in the biochemical profiles of the *Anopheles* and *Culex* larvae. Hira Amir et al. [14] reported the larvicidal activity of *Parthenium hysterophorus* against *Aedes aegypti*. The stock solution of fresh and stored leaves was used to prepare the different concentrations. Both the solutions were effective against the *Aedes aegypti* but the concentrations made by fresh leaves were more effective as compared to stored leaves. Mohd Shazad et al. [15] indicated the lethal and efficient sublethal effects of extracts of *O. scantum* against *A. aegypti*. The extract showed the impact on the growth and development of the fourth instar larvae and delayed larval development. The larva-pupa intermediates and pupa-adult intermediates were also observed after the treatment of the extract.

Selladurai Subarani et al. [16] stated that the extracts of *C. roseus* prepared with the help of aqueous and methanolic solvents were used to control the *Anopheles* and *Culex*. The medicinal plant, *C. roseus* showed larvicidal as well as pupicidal activity. B. Sai Shankar et al. [17] worked on the local plants for checking their repellent activity against the mosquitoes. Depending on the traditional knowledge, the 5 different local plants like *Azadirachta indica*, *Murraya koenigii, Ocimum tenuifloreum*, *Citrus medica* and *Ricinus communis* were checked for their repellent activity against mosquitoes. Kamraj et al. [18] used the solvents like methanol, hexane, chloroform, acetone and ethyl acetate for preparing the herbal extracts of *Ocimum sanctum*, *Ocimum canum*, *Rhinacanthus nasutus* and *Citrus sinensis* to check larvicidal and repellent activity against the gram borer, malarial vector and cotton leaf roller. The findings show that all the extracts used in the experiment were showed larvicidal and repellant activity and are an eco-friendly method for controlling the different insect pests including the mosquitoes. Choi et al. [19] tested the essential oils of different plants like *Lovender officinalis*, *R. officinalis*, *Eucalyptus globulus* and *T. vulgaris* against *Culex pipiens* and found all of them with good repellant activity. Bhagavan et al. [20] in their study reported that *Culex tritaeniorhynchus*, *Anopheles subpictus* and *Aphis gossypii* can control by using the extracts of *O. canum*, *C. sinensis*, *Rhinacanthus nasutus* and *O. sanctum*. All these plants showed larvicidal and nymphicidal activity against the mosquito vector and cotton pest. The larvicidal, pupicidal and ovicidal activities of the methanolic extracts were more toxic than acetone extracts of *Eranthemum roseum* against *A. stephensi*. The larvicidal, pupicidal and ovicidal activities of the methanolic and acetone extracts of *Eranthemum*

roseum were studied by Elumalai et al. [21]. Zahir et al. [22] reported the adulticidal activity of some seed extracts against *A. stephensi* which includes the plants like *Anisomeles malabarica*, *R. communis*, *Tridex procumbens*, *E. hirta*, *O. basilicum*, *Solanum trilobatum* and seeds of *Gloriosa superb*.

Suganya et al. [23] reported the larvicidal activity of *Leucas aspera* with the solvent leaf extracts and silver nanoparticles against the fourth instar larvae of *Aedes aegypti*, results revealed that synthesized nanoparticles showed more larvicidal activity as compared to the crude extract. Hence they said that the use of silver nanoparticles prepared can be controlled effectively. Poophati et al. [24] checked the larvicidal activity of silver nanoparticles synthesized from the aqueous leaf extract of *A. indica* against *A. aegypti* and *Culex quinquefaciatus*. The nanoparticles prepared by neem were used to control the two species of mosquitoes. Sivapriyajothi et al. [25] synthesized and characterized the silver nanoparticles from the leaf extracts of *L. aspera* to find out its lethal concentration against first to fourth instar larvae and pupae of *Anopheles stephensi* and *Aedes aegypti*. Santosh et al. [26] used the silver nanoparticles and aqueous crude extracts of *Annona muricata* to study the larvicidal activity against three mosquito species. Naik et al. [27] reported the larvicidal activity of silver nanoparticles from the leaf extracts of *Pongamia pinnata*. Krishanappa et al. [28] showed larvicidal, pupicidal and ovicidal activity due to ethanolic extracts of *Gliricidia sepium* against third instar larvae of *A. stephensi*. Thangarasu et al. [29] studied the larvicidal and ovicidal activities of *Clausena excavata* against *S. litura*, *C. quinquefaciatus*, *A. aegypti* and *A. stephensi. Gaultheria* oil showed larvicidal, pupicidal and repellent activities against the first, second, third and fourth instar larvae and pupae of *C. quinquefasciatus* was reported by Aruna et al. [30].

Krishanappa et al. [31] studied the larvicidal and repellent activity of methanolic extracts of *Adansonia digitata* against *A. stephensi*. Phytochemicals like saponins, flavonoids, steroids, tannins and anthraquinones from powdered *C. mimosoides* showed the larvicidal effect on *A. gambiae*. The plant extract showed the repellency against the adult A. *gambiae* studied by Alayo MA [32]. Govindrajan and Sivakumar [33] reported the presence of repellent activity of plants like *Eclipta albo* and *A. paniculata* against the adult *A. stephensi* mosquitoes. 25 essential oils were tested for their larvicidal activity and knockdown effects against the *C. quinquefasciatus*, *A. aegypti* and *A. stephensi* it was reported by Manimaran A. et al. [34]. Mavundza et al. [35] observed the adulticidal activity in the dichloromethane extract and ethanol extract of ten plants from South Africa which are used traditionally in mosquito control. From their results, it was observed that the dichloromethane extracts and ethanolic extract of leaves of *Aloe ferox* leaves showed the highest mosquito mortality. Jang et al. [36] reported more than 90% mortality in *Aedes aegypti* and *Culex pipiens* when exposed to methanolic extracts of *C. tora*, *Cassia obtusifolia* and *Vicia tetrassperma*. The concentration of extracts was 200 ppm at which the larvae showed the 90% mortality.

Ramar et al. [37] reported the use of various concentrations of different essential oils of *Pimpinella anisum*, *A. calamus*, *Citrus limon*, *C. sinensis*, *C. nardus*, *Cinnamomum verum*, *T. vulgaris*, *O. sanctum*, *Vetiveria zizaniodes* and *Myrtus caryophyllus* against the *Culex quinquefaciatus*. All the said oils showed ovicidal activity and oviposition responses were also recorded. The essential oils of aniseed, clove and cinnamom showed the highest ovicidal activity against the *Culex quinquefaciatus*. El-Akhal et al. [38] analyzed the essential oil of *O. majorana* by GC-MS for finding chemical compositions present in it. Many compounds tested for their larvicidal activity showed the moderate larvicidal activity against *Culex pipens*. In the study of Carvalho Kda et al. [39] essential oil of *Croton tetradenius* showed insecticidal activity against the larva of *A. aegypti*. Larvicidal effect of *Lawsonia inermis* on early and late larval stages of *A. stephensi* was reported by Bakhshi et al. [40]. Reeegan et al. [41] reported methanol, ethyl acetate and hexane leaves extract of *S. indicus*, *A. marmelos*, *L. acidissima*, *Sphaeranthus amaranthoides* and *C. odorata* for its ovicidal and oviposition deterrent activities against *A. Aegypti* and *C. quinquefasciatus*. The results revealed that the hexane extract of *L. acidissima* against the vector showed 100% oviposition deterrent while five plant extracts showed significantly highest ovicidal activity. Essential oils extracted from *Tridex procumbens* showed the repellency effect against the malarial vector was reported by S. Rajkumar and A. Jebanesan [42]. M.A.Ansari et al. [43] reported the larvicidal activity of essential oil from Mentha piperita against the third instar larvae of *Culex quinquefaciatus*, *Anopheles stephensi* and *Aedes aegypti*. The result of their study state that *Culex* was most susceptible as compared to the other two species of mosquitoes. The oil also showed adult repellency.

F. Erler et al. [44] reported the adult repellency of females of *Culex pipiens* after the application of essential oils from the seeds of *Pimpinella anisum*, *Mentha piperita*, *Ocimum basilicum*, *Laurus nobilis* and *Eucalyptus camaldulensis*. The effects of leaf and seed benzene, hexane, chloroform, ethyl acetate and methanol extract of *Delonix elata* on repellent activity against *Anopheles stephensi* was tested and reported by Marimuthu Govindarajan et al. [45]. In their study they reported the strength of the extract was responsible for the repellent activity of the extract. The leaf and seed extracts showed 210 and 180 min protection at 5.0 mg/cm^2 respectively since the crude extract of *D. elata* exhibit the potential for controlling *Anopheles stephensi*. Kalimuthu kovendan et al. [46] for the first time reported the ovicidal, adulticidal and repellent activity of *Acalypha alnifolia* against malaria, filarial and dengue vector. Duraisamy Amerasan et al. [47] reported that *Cassia tora* showed repellent and adulticidal property against three mosquito vectors. Abdallah F Traboulsi et al. [48] used oils from leaves and flowers of aromatic plant extracts against the 4th instar larvae of *Culex pipiens* to determine their insecticidal activities. The extracts showed the toxicity, extracts of *Myrtus communis* were most toxic followed by *Origanum syriacum* L., *Mentha*

microcorphylla Koach, *Pistacia lentiscus* L and *Lavandula stoechas*. Eight out of twenty components of essential oil were showed the insecticidal property against the larvae.

Rattanam AhbiRami et al. [49] reported the larvicidal efficacy of different extracts of the plant parts of *Ipomoea cairica* using solvents like acetone and methanol against 3rd instar larvae of *Aedes albopictus* and *Aedes aegypti*. They concluded that *I. cairica* extract posses larvicidal potential for a more eco-friendly control program of *Aedes* mosquitoes. Roark RC [50] stated that approximately 1200 plants having insecticidal property. Sukumar et al. [51] reported the presence of mosquitocidal properties in 344 plants. Sarita Kumar et al. [52] in their study evaluated that hexane and petroleum ether extracts of roots of *N. jatamansi* showed the larvicidal effect against the early 4th instar larvae of *Aedes aegypti*. The result showed the highest toxicity of petroleum ether root extracts as compared to the hexane root extracts.

Aksorn Chantawee and Mayura Soonwera [53] evaluated efficacies of essential oils of four plants as a larvicide, pupicide and oviposition deterrent activity against *Aedes aegypti*. In their experiment, they used rhizome of *Alpinia galangal*, fruits of *Foeniculum vulgare*, *Anthum graveolens* and *Pimpinella anisum* for the preparation of extracts. Among all the extracts *Anthum graveolens* showed the highest larvicidal activity. *Anthum graveolens* oil did not only act as a larvicide but it was also acting as a pupicide and oviposition deterrent agent was stated by Aksorn Chantawee and Mayura Soonwera[53]. S. Arivoli and Samuel Tennyson [54] evaluated the larvicidal activity of crude leaf extracts of *Abutilon indicum* as well as it was responsible for pupal deformities and adult emergence inhibition activity against *Culex quinquefasciatus*, *Aedes aegypti* and *Anopheles stephensi*. The extracts were helpful for arresting the larval and pupal development resulting in the decreased pupal transformation and adult emergence, larval-pupal and pupal-adult intermediates were recorded with increased developmental periods.

Jazem A Mahyoub [55] studied the effect of three seaweed extracts sea grass *Thalassia hemprichii*, gray Mangrove *Avicennia marina* and Sea lettuce *Ulva lactuca* against 4th instar larvae of *Anopheles dthali*. Out of the three *Avicennia marina* proved to be more effective to inhibit the emergence of adult mosquitoes survived from larval treatment, followed by *Thalassia hemprichii* and *Ulva lactuca*. Though all these three seaweeds act as a larvicide against the *Anopheles dthali* but they were safe for the aquatic nontarget organisms prevailing in mosquito breeding sites.

The larvicidal effects of the extract of *Azolla pinnata* against 4th instar larvae of *Aedes* was reported by Rajiv Ravi et al. [56]. In their study they used two different methods of extraction, Soxhlet extraction which is more effective over maceration extraction method. They also reported that the extracts were nontoxic in the case of nontarget organisms like guppy fish. M.S. Mohamed Jaabir et al. [57] demonstrated that the coelomic fluid of *Eudrilus*

eugeniae had the larvicidal property which was used to control the *Anopheles* mosquito vector species. Coelomic fluid not only affects the growth and development of the larvae but it also affects abnormalities in the movement of the larvae. Robert R. Jackson and Fiona R. Cross [58] stated that two spider species that naturally feeds on mosquitoes may use as a predator to control the malarial vector. The researchers also stated that the use of spiders in mosquito control programs is a very innovative idea. Jazem A. Mahyoub et al. [59] evaluated some marine extracts against *Aedes aegypti* and reported that the ethanolic extract of sea grass *T. hemprichii* is less effective as compare to the ethanolic extract of the sea cucumber *H. atra* as an insecticide. Chinnasamy et al. [60] in their study focused on the evaluation of mosquito larvicidal efficacy of metabolites of several Indigenous fungal isolates like *Aspergillus niger*, *Penicillium species*, *Rhizopus sp.*, *Aspergillus flavus*, *Mucor* sp., *Aspergillus parasiticus* and *Aspergillus* sp. on the larvae of *Aedes aegypti* and *Culex quinquefasciatus* under laboratory condition. *Penicillium* species show a better larvicidal effect as compared to other fungi. Larvicidal activity of mycelial ethyl Acetate extract of *Penicillium* species was checked against 1st to 4th instar larvae of *Aedes aegypti* and *Culex quinquefasciatus.*

Conclusion

Ecological safety is considered to be of the highest concern today. In order to be appropriate, an insecticide does not need to cause raised mortality in target species but should be eco-friendly in nature. Phytochemicals can also be used in parts of the world as they would be relatively safe, inexpensive and readily available. Several plants in many parts of the world are used traditional medicines for larvicidal mosquito activities. In addition to the phytochemicals, several other species have also been included in the program for mosquito control. In order to reduce the vector population and the severity of epidemiology, synergetic approaches such as the application of mosquito predators with botanical blends and microbial pesticides would provide a better impact.

References

1. Sukumar K, Perich MJ, Boober LR (1991) Botanical derivatives in mosquito control: A Review. J American Mosquito Control Association, 7:210-137.
2. Ignacimuthu S. (2000) The roots of botanicals in combating mosquitoes. Abstracts : Proceedings of symposium on recent trends in combating mosquitoes, Loyola College, Chennai, India, 19.
3. Markouk M, Bekkouche K, Larhsini M, Bousaid M, Larzek HB,Jana M, (2000) Evaluation of some Moroccan medicinal plant extracts for larvicidal activity. J Ethnopharmacol, 73:293-297.

4. De Omena MC, Navarro DM, de Paula JS, Ferreira de Lima MR, et al (2007) Larvicidal activites against *Aedes aegypti* of some Brazalian medicinal plants. Bioresours Technol 98: 2549-2556.
5. Dimopoulos G., Christophides GK, Meister S, Schultz J, White KP, et al (2002) Genome expression analysis of Anopheles gambiae: responses to injury, bacterial challenge & malaria infection. Proc Natl Acad Sci USA 99:8814-8819.
6. Tetreau G, Alessi M, Veyrenc S, Perigon S, David JP, et al (2012) Fate of Bacillus thuringenesis subsp israelensis in the field evidence for spore recycling differential persistence of toxins in leaf litter. Appl Environ Microbiol 78:8362-8367.
7. Deepak Kumar, Rakesh Chawala, P Dhamodaram & N Balakrishanan (2014) Larvicidal activity of Cassia occidentalis (Linn.) against the Larvae of Bancroftian Filariasis Vector Mosquito *Culex quinquefasciatus*. Journal of parasitology Research Vol. Feb 2014.
8. Alouani A, Rehimi N, Soltani N (2009) Larvicidal activity of a Neem tree extract (Azadirachtin) against mosquito larvae in the republic of Algeria. Jorden J Biological Sci 2: 15-22.
9. Okigbo RN ,Okeke JJ, Madu NC (2010) Larvicidal effects of Azadirachta indica, Ocimum gratissimum & Hyptissu aveolens against mosquito larvae. J Agric Technol 6:703-719.
10. Maragathavalli S, Brindha S, Kaviyarasi NS, Annadurai B, Gangwar SK (2012) Mosquitoes larvicidal activity of leaf extract of neem (Azadirachta indica). International J Adv Biol Res 2: 138-142.
11. Monzon RB, Alvior JP, Luczon LL, Morales AS, Mutuc FE (1994) Larvicidal potential of five Philippine plants against Aedes aegypti (LINN.) & *Culex quinquefasciatus*. Southeast Asian J Trop Med Public Health 25: 755-759.
12. Ragavendran C, Manigandan V, Kamaraj C, Balasubramani G, Prakash JS, Perumal P and Natarajan D (2019) Larvicidal, Histopathological, Antibacterial Activity of Indigenous Fungus Penicillium sp. Against Aedes aegypti L and Culex quinquefasciatus (Say) (Diptera: Culicidae) and Its Acetylcholinesterase Inhibition and Toxicity Assessment of Zebrafish (Danio rerio). Front. Microbiol. 10:427. doi: 10.3389/fmicb.2019.00427
13. Preeti Sharma, Lalit Mohan, Kamal Kumar Dua, Chand Narayan Srivastava (2011) Status of carbohydrate, protein and lipid profile in the mosquito larvae treated with certain phytoextracts Asian Pacific Journal of Tropical Medicine 301-304.
14. Hira Amir, Beenish Zia Butt and Seemal Ejaz Vehra (2017) Evaluation of larvicidal activity of Parthenium hysterophorus against Aedes aegypti. IJMR; 4(2): 01-04.
15. Mohd Shazad, Kamal Kumar Gupta, Sunil Kayesth and Shailendra Kumar (2018) Sublethal Effects of Ethanol Extract of Ocimum sanctum on Laboratory Bred

Population of Dengue Mosquito Aedes aegypti L. (Diptera: Culicidae) Vector Biol J, 3:1 DOI: 10.4172/2473-4810.1000128

16. Selladurai Subarani, Selvi Sabhanayakam, Chinnaperumal Kamaraj, Gandhi Elango, Mohamed Abdul Kadir (2013) Efficacy of larvicidal and pupicidal activity of Catharanthus roseus aqueous and solvent extracts against Anopheles stephensi Liston and Culex quinquefasciatus Say (Diptera: Culicidae). Asian Pacific Journal of Tropical Medicine 625-630.
17. B. Sai Shankar , T. Saravanan , M. Ragavi , G. Kaviya , Ankita Anushree , Arul Samraj , Samuel Tennyson (2013) Screening of Local Plants for Their Repellent Activity against Mosquitoes (Diptera: Culicidae), Journal of Mosquito Research, Vol.3, No.14, 97-104.
18. Kamaraj C, Rahuman A A, Bagavan A. (2008) Screening for antifeedant and larvicidal activity of plant extracts against Helicoverpa armigera (Hubner), Sylepta derogata (F.) and Anopheles stephensi (Liston). Parasitol Res; 103(6): 1361-8.
19. Choi WS, Park BS, Ku SK, Lee SE. (2002) Repellent activities of essential oils and monoterpenes against Culex pipiens pallens. J Am Mosq Control Assoc; 18(4): 348-51.
20. Bagavan A, Kamaraj C, Rahuman AA, Elango G, Zahir AA, Pandiyan G. (2009) Evaluation of larvicidal and nymphicidal potential of plant extracts against Anopheles subpictus Grassi, Culex tritaeniorhynchus Giles and Aphis gossypii Glover. Parasitol Res; 104(5): 1109-17.
21. Elumalai K, Dhanasekaran S, Anandan A, Krishnappa K, Gokulakrishnan J, Elangovan A. (2012) Larvicidal, ovicidal and pupicidal activity of Eranthemum roseum (Vahl) R. Br. against malarial vector mosquito, Anopheles stephensi (Liston) (Diptera: Culicidae). Int J Curr Agric Sci; 2(7): 28-33.
22. Zahir AA, Rahuman AA, Bagavan A, Elango G, Kamaraj C. (2010) Adult emergence inhibition and adulticidal activities of medicinal plant extracts against Anopheles stephensi Liston. Asian Pac J Trop Med; 3(11): 878-83.
23. Suganya G, Karthi S, Shivakumar MS. (2014) Larvicidal potential of silver nanoparticles synthesized from Leucas aspera leaf extracts against dengue vector Aedes aegypti. Parasitol Res; 113(3): 875-80.
24. Poopathi S, De Britto LJ, Praba VL, Mani C, Praveen M. (2015) Synthesis of silver nanoparticles from Azadirachta indica – a most effective method for mosquito control. Environ Sci Pollut Res; 22(4): 2956-63.
25. Sivapriyajothi S, Mahesh Kumar P, Kovendan K, Subramaniam J, Murugan K. (2014) Larvicidal and pupicidal activity of synthesized silver nanoparticles using Leucas aspera leaf extract against mosquito vectors, Aedes aegypti and Anopheles stephensi. J Entomol Acarol Res; 46: 77-84.

26. Santhosh SB, Ragavendran C, Natarajan D. (2015) Spectral and HRTEM analyses of Annona muricata leaf extract mediated silver nanoparticles and its larvicidal efficacy against three mosquito vectors Anopheles stephensi, Culex quinquefasciatus, and Aedes aegypti. J Photochemi Photobiol; 153: 184-90.
27. Naik BR, Gowreeswari GS, Singh Y, Satyavathi R, Daravath SS, Reddy PR. (2014) Bio-synthesis of silver nanoparticles from leaf extract of Pongamia pinnata as an effective larvicide on dengue vector Aedes albopictus(Skuse) (Diptera: Culicidae). Adv Entomol; 2: 93-101.
28. Krishnappa K, Dhanasekaran S, Elumalai K. (2012). Larvicidal, ovicidal and pupicidal activities of *Gliricidia sepium* (Jacq.) (Leguminosae) against the malarial vector, *Anopheles stephensi* Liston (Culicidae: Diptera). Asian Pacific Journal Trop Med, 5(8):598-604. doi: 10.1016/S1995-7645(12)60124-2.
29. Thangarasu M, Kaliyamoorthy K, Kuppusamy E. (2014) Pesticidal and mosquitocidal activities of Clausena excavata Burm. F. (Rutaceae) against *Spodoptera litura* (Fab.) (Noctuidae: Lepidoptera) and *Aedes aegypti* L., *Anopheles stephensi* Liston, and *Culex* quinquefasciatus. Say. (Diptera: Culicidae). Adv Zool; doi: 10.1155/2014/745015.
30. Aruna P, Murugan K, Priya A, Ramesh S. (2014) Larvicidal, pupicidal and repellent activities of Gaultheria oil (Plantae: Ericaceae) against the filarial vector, Culex quinquefasciatus (Insecta: Diptera: Culicidae). J Entolomol Zool Stud; 2(4): 290-4.
31. Krishnappa K, Elumalai K, Dhanasekaran S, Gokulakrishnan J. (2012) Larvicidal and repellent properties of Adansonia digitata against medically important human malarial vector mosquito Anopheles stephensi (Diptera: Culicidae). J Vector Borne Dis; 49: 86-90.
32. Alayo MA, Femi-Oyewo MN, Bakre LG, Fashina AO (2015) Larvicidal potential and mosquito repellent activity of Cassia mimosoides extracts. Southeast Asian J Trop Med Public Health; 46(4): 596-601.
33. Govindarajan M, Sivakumar R. (2011) Mosquito adulticidal and repellent activities of botanical extracts against malarial vector, Anopheles stephensi Liston (Diptera: Culicidae). Asian Pac J Trop Med; 4(12): 941-7.
34. Manimaran A, Jee Jee Cruz M, Muthu C, Vincent S, Ignacimuthu S. (2012) Larvicidal and knockdown effects of some essential oils against *Culex quinquefasciatus* Say, Aedes aegypti (L.) and Anopheles stephensi (Liston). Adv Biosci Biotechnol; 3: 855-62.
35. Mavundza EJ, Maharaj R, Chukwujekwu JC, Finnie JF, Van Staden J. (2014) Screening for adulticidal activity against Anopheles arabiensis in ten plants used as mosquito repellent in South Africa. Malar J; 13: 173.

36. Jang YS, Jeon JH, Lee HS (2005) Mosquito larvicidal activity of active constituent derived from Chamaecyparis obtusa leaves against 3 mosquito species. J Am Mosq Control Assoc 21: 400-403.
37. Ramar M, Ignacimuthu S, Gabriel Paulraj M. (2014) Ovicidal and oviposition response activities of plant volatile oils against Culex quinquefasciatus say. J Entomol Zool Stud; 2(4): 82-6.
38. El-Akhal F, El Ouali Lalami A, Ez Zoubi Y, Greche H, Guemmouh R. (2014) Chemical composition and larvicidal activity of essential oil of Origanum majorana (Lamiaceae) cultivated in Morocco against Culex pipiens (Diptera: Culicidae). Asian Pac J Trop Biomed; 4(9):746-50.
39. Carvalho Kda S, E Silva SL, de Souza IA, Gualberto SA, da Cruz RC, Dos Santos FR, et al. (2016) Toxicological evaluation of essential oil from the leaves of Croton tetradenius (Euphorbiaceae)on Aedes aegypti and Mus musculus. Parasitol Res; 115(9):3441-8.
40. Bakhshi H, Abai MR, Amin G, Zolfi R, Pirmohammadi M, Bakhshi A, et al. (2014) Larvicidal properties of botanical extracts of Lawsonia inermis against Anopheles stephensi. Adv Infect Dis; 4: 178-85.
41. Reegan AD, Gandhi MR, Paulraj MG, Ignacimuthu S. (2015) Ovicidal and Oviposition deterrent activities of medicinal plant extracts against Aedes aegypti L. and Culex quinquefasciatus say mosquitoes (Diptera: Culicidae). Osong Public Health Res Perspect; 6(1): 64-9.
42. S. Rajkumar and A. Jebanesan. (2007) Repellent activity of selected plant essential oils against the malarial fever mosquito Anopheles stephensi. Tropical Biomedicine, 24(2), 71–75.
43. M.A. Ansari, Padma Vasudevan, Mamta Tandon, R.K. Razdan (2000) Larvicidal and mosquito repellent action of peppermint (Mentha piperita) oil Bioresource Technology 71, 267- 271.
44. F. Erler, I. Ulug, B. Yalcinkaya F. Erler, I. Ulug, B. Yalcinkaya (2006) Repellent activity of five essential oils against Culex pipiens Fitoterapia 77, 491–494.
45. Marimuthu Govindarajan , Mohan Rajeswary, Rajamohan Sivakumar (2015) Repellent properties of Delonix elata (L.) Gamble (Family: Fabaceae) against malaria vector Anopheles stephensi (Liston) (Diptera: Culicidae) Journal of the Saudi Society of Agricultural Sciences 14, 128–133.
46. Kalimuthu Kovendan & Kadarkarai Murugan & Palanisamy Mahesh Kumar & Perumal Thiyagarajan & Samuel John William (2013) Ovicidal, repellent, adulticidal and field evaluations of plant extract against dengue, malaria and filarial vectors Parasitol Res 112:1205–1219 DOI 10.1007/s00436-012-3252-8

47. Duraisamy Amerasan & Kadarkarai Murugan & Kalimuthu Kovendan & Palanisamy Mahesh Kumar & Chellasamy Panneerselvam & Jayapal Subramaniam & Samuel John William & Jiang-Shiou Hwang (2012) Adulticidal and repellent properties of Cassia tora Linn. (Family: Caesalpinaceae) against Culex quinquefasciatus, Aedes aegypti, and Anopheles stephensi Parasitol Res 111:1953–1964. DOI 10.1007/s00436-012-3042-3
48. Abdallah F Traboulsi,K Taoubi, Samih El-Haj,JM Bessiere and Salma Rammal Insecticidal properties of essential plant oils against the mosquito Culex pipiens molestus (Diptera: Culicidae). Pest Manag Sci 58: 491-495. DOI: 10.1002/PS.486
49. Rattanam Ahbi Rami,Wan Fatma Zuharah, Maniam Thiagaletchumi, Sreeramanan Subramaniam and Jeevandran Sundarasekar (2014) Larvicidal Efficacy of Different Plant Parts of Railway Creeper, Ipomoea cairica Extract Against Dengue Vector Mosquitoes, Aedes albopictus (Diptera: Culicidae) and Aedes aegypti (Diptera: Culicidae) J. Insect Sci. 14(180): DOI: 10.1093/jisesa/ieu042
50. Roark RC. Some promising insecticidal plants. Econ Bot 1947; 1 : 437-45.
51. Sukumar K, Perich MJ, Boobar LR. (1991) Botanical derivatives in mosquito control: a review. J Am Mosq Control Assoc; 7 : 210-37.
52. Sarita Kumar, Aarti Sharma and Radhika Warikoo. (2018) Potential of Nardostachys jatamansi Extracts to Manage Indian Strain of Aedes aegypti: A Novel Approach for Vector Control. Vector Biol J, 3:1 DOI: 10.4172/2473-4810.1000129
53. Aksorn Chantawee, Mayura Soonwera (2018) Efficacies of four plant essential oils as larvicide, pupicide and oviposition deterrent agents against dengue fever mosquito, Aedes aegypti Linn. (Diptera: Culicidae). Asian Pacific Journal of Tropical Biomedicine; 8(4): 217-225.
54. S. Arivoli and Samuel Tennyson (2011) Larvicidal and adult emergence inhibition activity of Abutilon indicum (Linn.) (Malvaceae) leaf extracts against vector mosquitoes (Diptera: Culicidae) Journal of Biopesticides, 4 (1): 27 - 35
55. Jazem A Mahyoub (2018) Mosquito Larvicidal activity of seaweed extracts against Anopheles dthali with reference to its side effects on aquatic nontraget organisms. International Journal of Mosquito Research; 5(6): 34-38
56. Ravi R, Zulkrnin NSH, Rozhan NN, Nik Yusoff NR, Mat Rasat MS, Ahmad MI, et al. (2018) Chemical composition and larvicidal activities of Azolla pinnata extracts against Aedes (Diptera: Culicidae). PLoS ONE 13(11): e0206982.
57. M.S. Mohamed Jaabir, S. Ramu, N. Shabeer, S. Shantkriti, S. Senthil Kumar (2014) Preliminary evaluation of the larvicidal efficacy of coelomic fluid of Eudrilus eugeniae on anopheles mosquito. International Journal of Pharmaceutical Science InventionVolume 3 Issue 8 ǁ August 2014 ǁ PP.20-27.
58. Robert R. Jackson and Fiona R. Cross (2015) REVIEW Mosquito-terminator spiders and the meaning of predatory specialization. Journal of Arachnology 43:123–142.

59. Jazem A. Mahyoub, UsamaW. Hawas, Khalid M. Al-Ghamdi, Mohammad M. E. Aljameeli, Fekri M. Shaher, Muneer A. Bamakhrama and N.A. Alkenani (2016) The Biological Effects of Some Marine Extracts Against Aedes aegypti (L.) Mosquito Vector of the Dengue Fever in Jeddah Governorate, Saudi Arabia J Pure Appl Microbio, 10(3), September 2016.
60. Chinnasamy Ragavendran, Venkatesan Manigandan, Chinnaperumal Kamaraj, Govindasamy Balasubramani, Joy Sebastain Prakash, Pachiappan Perumal and Devarajan Natarajan (2019) Larvicidal, histopathological, Antibacterial activity of Indigenous fungus Penicillium sp. against Aedes aegypti L and Culex quinquefaciatus (Say) (Diptera: Culicidae) and its Acetylcholinesterase inhibition and toxicity assessment of Zebrafish (Danio rerio) Front. Microbiol., 18 March 2019 | https://doi.org/10.3389/fmicb.2019.00427